LATITUDINAL EFFECTS ON METABOLIC RATES IN THE CRICKET FROG, *ACRIS CREPITANS:* ACUTELY MEASURED RATES IN SUMMER FROGS

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If a poikilothermic animal could not compensate for temperature in metabolic activity, the rates of chemical reactions and the rates of various activities of the organism could be expected to be proportional to the temperatures to which the animal is exposed. It is, however, well documented that a great variety of poikilothermic animals can compensate for temperature in various physiological activities (Bullock, 1955; Precht, Christophersen and Hensel, 1955; Prosser, 1964). Northern populations of the same or closely related species often have higher rates of activity than southern populations measured at the same temperature. As a result, northern and southern populations may have similar rates of activity although they are living in very different thermal environments (Bullock, 1955; Precht, 1958; Vernberg, 1962).

The compensation for temperature in physiological activities which may be encountered among populations from different latitudes is frequently found to be stable and the differences are assumed to be genetically determined. On the other hand, the response of an individual organism to temperature may be dependent upon the temperatures to which the animal was previously exposed. Any such acclimation effect must be ruled out before differences between geographically separated populations can be considered to have a genetic basis.

Several investigators have compared the metabolic rates of latitudinally or altitudinally separated populations of the same or different species of Anura. Thus, Tashian and Ray (1957) reported differences in the rates of oxygen consumption between adults of northern and southern species of frogs. In addition, Tashian and Ray (1957) compared northern and southern subspecies of *Bufo boreas* while Packard (1971) compared montane and piedmont populations of *Pseudacris triseriata.* Significant differences were not found in either case. However, Jameson, Taylor and Mountjoy (1970) report a great deal of variability in metabolic rates between populations of the frog, *Hyla regilla,* from localities extending from British Columbia to Baja California. They found no clear-cut correlation between latitude and metabolic rate but did find that frogs from localities which were similar with respect to climate showed similar degrees of metabolic adjustment and tended to differ markedly from frogs from climatically different regions.

In the examples cited, the possibilities that genetically fixed latitudinal and short-term acclimation effects would be confounded were reduced by comparing animals acclimated at the same temperature under controlled conditions in the laboratory. Nonseasonal thermal acclimation of the metabolic rate has been reported

for a number of anurans and is often quite pronounced. A partial compensation for temperature in the metabolic rate has been reported for several species of *Rana* (Stangenberg, 1955; Rieck, Belli and Blaskovics, 1960; Jankowsky, 1960) and for *Bufo boreas* (Bishop and Gordon, 1957). In these anurans, animals which were acclimated at low temperatures were reported to have a higher metabolic rate when measured at an intermediate temperature than those acclimated at a higher temperature. On the other hand, *Rana esculenta* sampled in the summer (Locker and Weish, 1966; Stangenberg, 1955: Table 1) and *Acris crepitans* (Dunlap, 1969, 1971), have been reported to exhibit inverse compensation. In this case, frogs acclimated at high temperatures have higher metabolic rates when measured at an intermediate temperature than those acclimated at lower temperatures.

Considering the taxonomic diversity of the Anura and the wide-spread distribution of the order, there is a paucity of information on the relationship between latitude, climate and metabolic rates within the taxon. Furthermore, the majority of cases in which latitudinally related effects on metabolic rates have been reported have involved animals which exhibit partial compensation (Vernberg, 1962). There is, then, a need for more data on which to base hypotheses concerning the general significance of inverse compensation to those organisms in which it has been reported. Consequently, a comparison was made of the acutely measured metabolic rate–temperature curves of acclimated cricket frogs from two latitudinally widely separated populations. In this fashion it was expected that any obvious differences in acclimation pattern or in the metabolic responses of the two populations of frogs to changing temperatures would be demonstrated.

MATERIALS AND METHODS

Samples of cricket frogs were collected in July from near Vermillion, South Dakota (Latitude 42° 48'N, elevation 1,220 ft) and Austin, Texas (Latitude 30° 18'N, elevation 615 ft). Vermillion lies approximately 870 miles north of Austin.

Frogs from South Dakota were collected one to two days prior to placing them in the acclimation chambers. Texas frogs were collected, shipped to Vermillion via air express and placed in the acclimation chambers upon arrival. Groups of frogs were acclimated in the dark for 5–7 days (Dunlap, 1969) at experimental temperatures of 15° and 25° ± 1° C. They were maintained in loosely covered glass jars and had access to free water but were not fed during the course of acclimation. Oxygen consumption was measured for individual frogs using a refrigerated Gilson differential microrespirometer equipped with 100 ml flasks. Each flask received 5 ml deionized water in the animal chamber and carbon dioxide was absorbed by 1.5 ml 20% KOH placed in the side arm. The flasks were equilibrated for 30 min and readings were taken every 15 min for two hours. Stability of the system was routinely monitored by the insertion of a blank specimen vessel.

Metabolic rates are given as μl/g per hr STP of oxygen and are based on the average hourly uptake over the two hour period. These can best be considered as routine rates in the sense of Fry (1957) inasmuch as there was no control of spontaneous locomotor activity during the two hour period of determination. Measurements of oxygen consumption which are made within a few hours of transfer of the frogs from the acclimation temperature to the temperature of determination referred to as acute measurements and the corresponding rates as acute

rates following the terminology of Bullock (1955). Acclimated rates refer to rates calculated for animals in which the acclimation temperature and the temperature of determination are the same.

In the determination of the acutely measured metabolic rate-temperature (R-T) curves, oxygen consumption was measured at one of seven temperatures (5, 10, 15, 20, 25, 30 or 35 ± 0.1° C) for frogs acclimated at 15 or 25 ± 1° C. Each combination of acclimation temperature and determination temperature for each of the two localities was represented by a sample of six frogs. A different group of frogs was used for each set of determinations and each frog was used only once. These data, then, are based on 84 different frogs from each of the two localities or a total of 168 frogs.

Animals collected from each locality were assigned to each of the individual groups on a random basis with the restrictions that there should be approximately equal proportions of males and females and equal proportions of three arbitrarily assigned size classes within each group. Frogs from South Dakota averaged larger (1.5 g body wt) than those from Texas (0.5 g). The statistical techniques used in the analyses are from Li (1957) and Ostle (1963).

TABLE I

Mean metabolic rates in μl/g per hr and their standard errors for Acris crepitans *from South Dakota and Texas. The frogs were acclimated at 15 and 25°C and determined at the temperatures indicated. Each mean is based on a sample of six frogs. The data have not been corrected for differences in body weight*

Locality	Acclimation temp.	Determination temperature						
		5	10	15	20	25	30	35
South Dakota	15	35 ± 1.0	67 ± 8.1	77 ± 5.9	108 ± 7.8	160 ± 8.4	236 ± 12.4	349 ± 15.9
	25	56 ± 3.7	102 ± 7.2	154 ± 14.8	169 ± 10.3	169 ± 9.6	249 ± 16.8	332 ± 11.9
Texas	15	33 ± 2.1	66 ± 5.6	67 ± 6.6	156 ± 13.0	174 ± 15.2	226 ± 25.6	374 ± 37.0
	25	44 ± 5.0	80 ± 8.7	110 ± 6.6	173 ± 16.5	234 ± 46.0	220 ± 15.1	296 ± 11.8

RESULTS

The mean metabolic rates of the Texas and South Dakota frogs are shown in Table I. Since the mean body weights of frogs from the two localities were markedly different and since metabolic rate may be a weight-dependent variable in cricket frogs (Dunlap, 1969, 1971), comparisons among sets of data for any one determination temperature were made using a 2 × 2 analysis of covariance. In each analysis, mean metabolic rates are compared for samples of frogs from each locality, acclimated at 15 and 25° C and determined at one of the seven temperatures. Prior to analysis, the data were subjected to a $\log_{10}$ transformation for both metabolic rate and body weight. This transformation has the double effect of reducing the heterogeneity of the variances and of transforming the regression lines to a more linear form (Dunlap, 1971). Also, prior to the analysis, the hypothesis that the regression coefficients of the regression lines being compared are equal was tested and accepted ($P > 0.1$ in all cases). The results of the analyses are shown in

Table 11. Interaction was significant ($P < 0.05$) at determination temperatures of 20 and 35° C so these sets of data were analyzed further.

Locality comparisons

Differences in mean metabolic rates between Texas and South Dakota frogs were not significant at a determination temperature of 5° C or 25° C ($P > 0.25$ in each case). At 10 and 15° C, overall significance for locality was borderline ($P > 0.05, < 0.1$). If, however, metabolic rates of frogs acclimated at 25° C are compared separately from those of the 15° C frogs, the mean rate of the South Dakota frogs is significantly higher ($P < 0.05$) than that of the Texas animals. There is no significant difference attributable to locality when both samples are acclimated at 15° C and determined at either 10 or 15° C ($P > 0.25$). At 20° C

TABLE II

Mean squares, calculated F-ratios and their associated probabilities resulting from the 2 × 2 analysis of covariance of metabolic rates in Acris crepitans *following a log transformation of the data. The localities compared are Austin, Texas and Vermillion, South Dakota and the acclimation temperatures; 15 and 25°C. In each case metabolic rates were determined at the temperature indicated. For each analysis, the degrees of freedom are 1 and 19. Values in parentheses below the F-values represent probabilities*

Source of variation	Temperature of determination (°C)						
	5	10	15	20	25	30	35
Locality M.S.	0.0021	0.0387	0.0313	0.0069	0.0005	0.0466	0.0253
Acclimation M.S.	0.1890	0.0993	0.3462	0.0809	0.0148	0.0010	0.0242
Interaction M.S.	0.0005	0.0204	0.0135	0.0348	0.0054	0.0008	0.0128
Error M.S.	0.0111	0.0091	0.0100	0.0074	0.0145	0.0048	0.0025
F-ratios Locality	0.184 (>0.25)	4.251 ($>0.05; <0.1$)	3.127 ($>0.05; <0.10$)	0.908 (>0.25)	0.037 (>0.25)	9.765 (<0.01)	10.138 (<0.005)
Acclimation	16.950 (<0.001)	10.899 (<0.005)	34.629 (<0.001)	10.993 (<0.005)	1.023 (>0.25)	0.210 (>0.25)	9.722 (<0.01)
Interaction	0.048 (>0.25)	2.234 (>0.10)	1.350 (>0.25)	4.733 (<0.05)	0.374 (>0.25)	0.168 (>0.25)	5.153 (<0.025)

only the frogs acclimated at 15° C exhibited a significant difference attributable to locality ($P < 0.005$) with the Texas frogs having the higher rate. For frogs acclimated at 25° C and determined at 20° C there is no significant difference attributable to locality ($P > 0.25$). At 30° C the metabolic rates of frogs acclimated at both temperatures were significantly different for locality, with the South Dakota frogs having the higher rates ($P < 0.025$). At 35° C there is no significant difference for the 15° C frogs ($P > 0.1$) but locality differences are significant for the 25° C frogs ($P < 0.025$). The South Dakota animals have the higher rate.

Acclimation comparisons

The metabolic rates of frogs acclimated at 15 and 25° C are significantly different at 5, 10 and 15° C ($P < 0.005$), with the frogs acclimated at 25° C having
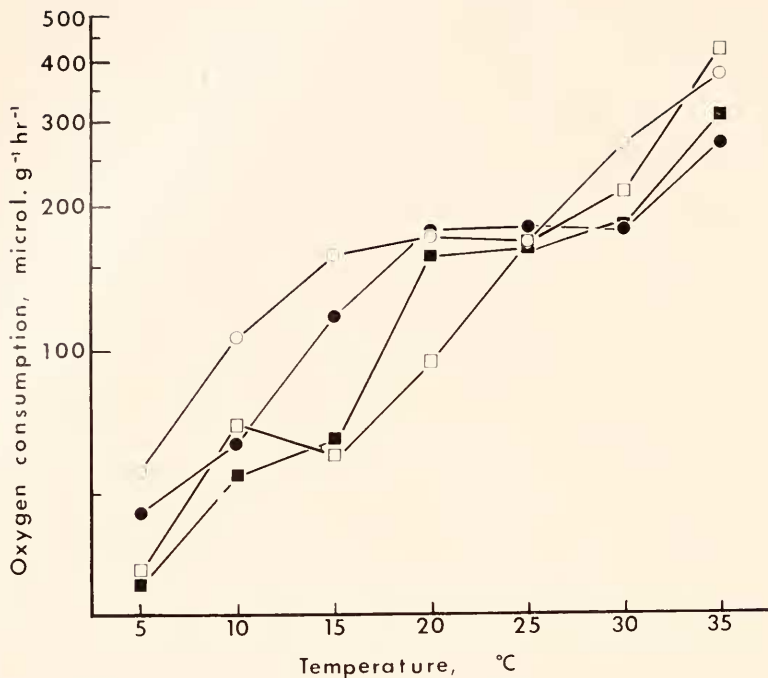
FIGURE 1. Routine oxygen consumption in *Acris crepitans* from Texas and South Dakota at various temperatures following acclimation at 15° and 25° C. Each point on the graph represents the predicted mean metabolic rate for frogs weighing 1 gram. Symbols representing the treatments are: Texas, 15° C (■); Texas, 25° C (●); S. D., 15° C (□); S. D., 25° C (○).

the higher rates. At 20° C acclimation effects are significant only for the South Dakota frogs ($P < 0.005$), with the 25° C acclimated frogs having the higher rates. At 25 and 30° C acclimation effects were not significant ($P > 0.25$) for either locality. At 35° C the South Dakota frogs showed no acclimation effects ($P > 0.1$) but the Texas animals did ($P < 0.025$). The frogs acclimated at 15° C have the higher rate.

The R-T curves for the four series (Texas frogs acclimated at 15 and 25° C, South Dakota frogs acclimated at 15 and 25° C) are shown in Figure 1. The mean rates used in the construction of the graph are the metabolic rates for frogs weighing 1 g predicted from the regression equation calculated from the data of each treatment. This figure illustrates the strikingly different metabolic responses of frogs acclimated at 15 and 25° C when oxygen consumption is measured at temperatures of less than 20° C for the Texas frogs and less than 25° C for the South Dakota frogs. Warm acclimated frogs from both Texas and South Dakota have a higher metabolic rate in this range of temperatures than do cool acclimated animals. The magnitude of the acclimation response is, however, greater for the South Dakota than for the Texas frogs. This is shown especially well when the R-T curves for the frogs acclimated at 25° C are compared. For frogs acclimated at 25° C, South

Dakota frogs have consistently higher metabolic rates than do Texas frogs when metabolic rates are determined at 5, 10, and 15° C. At determination temperatures above 25° C there are clearcut differences in metabolic responses of frogs from the two localities, with the Texas animals having the lower rates. At determination temperatures of 30 and 35° C no acclimation effects can be demonstrated for the South Dakota frogs. At 35° C, however, the cool acclimated Texas frogs have a slightly higher metabolic rate than the warm acclimated frogs.

Effects of acclimation on sensitivity of metabolic rates to temperature change

Since the curves of Figure 1 are plotted semilogrithmically, segments of lines with equal slopes represent temperature regions with equal Q_{10} values. Q_{10} values were calculated at 5° C intervals using the equation

$$Q_{10} = \left(\frac{V_1}{V_2}\right)^{[10/(t_1-t_2)]}$$

where V_1 and V_2 are metabolic rates corresponding to the temperatures t_1 and t_2. The calculated Q_{10} values for South Dakota and Texas animals acclimated at 15 and

TABLE III

Q_{10} values determined at 5°C intervals for Acris from South Dakota and Texas acclimated at 15 and 25°C

Acclimation temperature (°C)	Temperature interval (°C)					
	5–10	10–15	15–20	20–25	25–30	30–35
South Dakota frogs						
15	4.109	0.729	2.512	3.066	1.621	3.857
25	3.478	2.226	1.171	0.956	2.582	1.932
Texas frogs						
15	2.759	1.395	5.774	1.107	1.241	2.782
25	2.019	3.349	2.256	1.010	1.006	2.226

25° C are shown in Table III. Chemical reaction rates are usually more than doubled per 10° C increase in temperature (Prosser and Brown, 1961). Hence, a Q_{10} of less than 2 would indicate a relative insensitivity of metabolic rate to temperature change within the temperature range indicated. As might be surmised from an examination of the R-T curves, Q_{10} values of approximately 1.0 obtain between 15 and 25° C for the South Dakota frogs acclimated at 25° C and between 20 and 30° C for the 25° C Texas frogs. When frogs from both localities are acclimated at 15° C, Q_{10} values are low between 10 and 15° C. In the Texas animals the Q_{10} is low between 20 and 30° C as well. The latter plateau on the 15° C R-T curve is barely noticeable for the data from South Dakota frogs. For frogs acclimated at 15° C, segments of the R-T curves characterized by very low Q_{10} values are often immediately preceded by segments with high values, *e.g.*, the curve for Texas frogs between 20–30° C. In the R-T curves for frogs acclimated at 25° C, on the other hand, the transition between segments with high and those with low

Q_{10} values is less abrupt. The acclimated R-T curves for South Dakota and Texas *Acris* between 15 and 25° C are essentially identical and have a Q_{10} value of 2.8.

Discussion and Conclusions

Although the forms of the acutely measured R-T curves are complex, the curves of the South Dakota and Texas frogs in July show many similarities. They are also similar in form to those of South Dakota frogs determined in late May and early June (Dunlap, 1971). In each case, the same basic acclimation pattern is found. In Precht's (1958) terminology, the metabolic rates of *Acris* exhibit type V (inverse) compensation when the rates of warm acclimated (25° C) frogs are compared to those of cold acclimated (15° C) frogs at the lower temperature. Type IV (no) compensation, however, is evident when the metabolic rates of cold acclimated frogs are compared to those of warm acclimated animals at the higher temperature. This pattern is reflected in the intersection of the R-T curves which occurs at 20° C for the Texas frogs and 25° C for the South Dakota frogs. At temperatures below the intersection, warm acclimated frogs have a higher rate of oxygen uptake than do the cold acclimated animals. For South Dakota frogs, no acclimation effects are evident at the intersection of the R-T curves or at higher temperatures. Acclimation effects are absent between 20 and 30° C for Texas frogs. At 35° C, however, the cold acclimated Texas frogs have slightly higher rates than the warm acclimated frogs. As a result of this complex pattern of acclimation, the metabolic rates of warm acclimated frogs remain stable and Q_{10} values approximate 1 over a range in body temperature of at least 10° C. See Dunlap (1971) for a more detailed analysis of this acclimation pattern.

Cricket frogs are active both night and day and during the day may frequently be encountered basking in the sun at margins of ponds and small streams. Fitch (1956) reported that in northeastern Kansas, of 102 body temperatures recorded for *Acris* throughout the year, over half were between 28.0 and 31.7° C. In cool weather he found that body temperatures often exceeded air temperature by 10° C or more, but in warm weather the frogs basked less and body temperatures were usually nearer air temperature. Brattstrom (1963), on the basis of his own and Fitch's data, suggested that *Acris crepitans* may engage in thermoregulatory movements involving alternate basking and immersion in the water during the day and repeated immersion at intervals during the evening while water temperatures are higher than ambient air temperatures. The body temperatures of the frogs fluctuate less both daily and seasonally than might be expected on the basis of ambient temperature alone. Thus, Brattstrom (1963) measured body temperatures of Texas *Acris* between 0900 and 2300 hr and reported a mean body temperature of 24.9° C with a range from 30.0–22.0° C. During the same period, air temperature varied from a high of 27.0° C in the afternoon to a low of 21.5° C at night and water temperature varied from 27.2° C in the afternoon to 23.8° C at night. These data, then, suggest that *Acris* can, by behavioral thermoregulation, maintain a body temperature close to 30° C while the sun is shining. At night, however, body temperatures drop to levels that, on the average, lie between ambient air and water temperatures.

As we have seen, Texas frogs acclimated at 25° C are metabolically relatively insensitive to temperature change between 20 and 30° C. All of the values for body temperature given by Brattstrom and the bulk of Fitch's warm season values fall within these limits.

In an earlier paper (Dunlap, 1971), I suggested that inverse compensation together with the associated regions of metabolic insensitivity to temperature change enabled warm acclimated summer animals to maintain a high and relatively stable metabolic rate in spite of fluctuations in body temperature which occur between day and night and from day to day. Conversely, under conditions of constant and low temperature, as could be expected to occur during hibernation, the frogs would be cold acclimated and the relatively low rate of metabolism would result in a reduced rate of energy expenditure from energy reserves during the dormant period. The above interpretation is consistent with the available data on the body temperature of cricket frogs under field conditions. This model is based on the assumption that the frogs are warm acclimated throughout the summer. That is, they acclimate to their basking temperature or to a mean body temperature rather than to the lower temperature reached during the daily thermoperiod. Although I am aware of no experimental evidence for this with respect to metabolic acclimation, the work of Hutchison and Ferrance (1970) and Seibel (1970) lends credence to such an assumption. These investigators reported that in the frog, *Rana pipiens*, the critical thermal maximum responds to the maximum temperature when the frog is subjected to a daily thermoperiod.

In comparing the R-T curves of the 25° C acclimated frogs from South Dakota and Texas, it may be seen that the region of relative metabolic insensitivity to temperature extends from 20 to 30° C for the Texas animals and from 15 to 25° C for the South Dakota animals (Fig. 1). Furthermore, the metabolic rates of warm acclimated South Dakota frogs are higher than those of Texas frogs at all tested temperatures below 20 and above 25° C. These differences would seem to be accounted for by a simple translation of the R-T curve of the South Dakota frogs 5° to the left as compared to the Texas population. If the warm acclimated curve for the South Dakota frogs is moved 5° C to the right the two curves are essentially superimposed.

The mean maximum and minimum temperatures for July are 31.5 and 17.2° C, respectively, for Vermillion, South Dakota (Spuhler, Lytle and Moe, 1967) and 34.6 and 23.2° C for Austin, Texas (Blood, 1960). The differences noted above between the warm acclimated R-T curves of the northern (South Dakota) and the southern (Texas) populations, taken with the climatological data are consistent with the hypothesis of the role of metabolic patterns in the maintenance of metabolic stability in a varying thermal environment. If the thermoregulatory abilities of the two populations of frogs are similar, one could expect that in July the nocturnal body temperatures of the South Dakota frogs would, on the average, be lower than those of the Texas frogs. Yet, due to the shift of the curves for the South Dakota frogs to the left, nocturnal metabolic rates could be expected to average about the same for the two populations. Conversely, the mean maximum body temperatures of the Texas frogs might be expected to average somewhat higher during the day than those of the South Dakota animals. Under these conditions the depression of the metabolic rates of the Texas frogs at higher temperatures relative to the South

Dakota frogs would contribute toward the stabilization of the metabolic rates at higher body temperatures.

Except for the 20° C determination temperature, South Dakota and Texas frogs acclimated at 15° C do not differ significantly from each other. At 20° C the 15° C Texas animals behave metabolically as warm acclimated animals while the 15° C South Dakota frogs still have depressed rates. This difference in metabolic rates between samples from the two localities, if it proves to be characteristic of winter as well as summer animals, might be related to differences in degrees of winter activity of frogs at the two localities. In the Vermillion area *Acris* spends four to five months hibernating in ponds with body temperatures probably approximating 3° C (Dunlap, 1971). In the vicinity of Austin, frogs are active during all months of the year although the number of active frogs decreases in December and January (Pyburn, 1958). At temperatures above 5° C Dunlap (1971) found no significant differences in the metabolic rates of frogs acclimated at 5 and 15° C. If the acclimation pattern remains constant throughout the year, the abrupt increase in metabolic rate between 15 and 20° C in the Texas frogs would allow cold acclimated winter frogs to attain high metabolic rates and presumably high activity rates on warm sunny winter days. On the other hand, the South Dakota frogs would retain the depressed metabolic rates even in the face of brief periods of warm weather. If the northern populations were active during the occasional warm winter periods when the ice melts they would still be faced with a scarcity of food and the danger of being excluded from the hibernation pools when freezeup occurs again. Consequently, the greater constraints placed on the attainment of a high metabolic rate in the northern as compared to the southern population at moderate temperatures is, it seems to me, consistent with an adaptive interpretation of the metabolic and acclimation pattern.

The acclimated R-T curves between 15 and 25° C are almost identical for the two populations and with a Q_{10} of 2.8 exhibit no metabolic compensation for temperature. Dunlap (1971) has suggested that this may relate to the fact that these small frogs live in an environment of pronounced thermal instability. Consequently, body temperature could be expected to equal acclimation temperature for only a part of the time that the frog is active. This is, of course, quite different from Bullock's (1955) model which applies to environments such as the oceans in which environmental temperatures are much more stable and change slowly with the seasons. Under these conditions Bullock suggested that the acclimated R-T curves would exhibit temperature compensation.

The Texas and South Dakota populations of *Acris crepitans* are both placed in the subspecies *A. c. blanchardi* (Conant, 1958). This arrangement is supported on the basis of their general morphological (Harper, 1947) and biochemical (Dessauer and Nevo, 1969) similarity. However, populations of frogs from Texas tend to be more polymorphic for transferrins and slow esterases than the South Dakota populations (Dessauer and Nevo, 1969). Further, the two populations differ with respect to the predominance of one or the other of the alleles of the H subunit locus of lactate dehydrogenase (Salthe and Nevo, 1969). The one South Dakota population studied is monomorphic for one form of HLDH while Texas populations tend to be either monomorphic for the other form or are polymorphic. This is of special interest in view of the growing body of evidence for the function of enzyme variants

in minimizing the sensitivity of a given reaction to temperature. Hochachka and Somero (1968), for example, suggest that enzyme variants (*c.g.*, LDH enzymes) are induced during short-term acclimation and the same variants may be differentially selected by different populations during evolutionary adaption to different regional climates.

The results of the present study are in general agreement with the studies cited above. The South Dakota and Texas frogs show an overall similarity in acclimation pattern, as reflected in the acutely measured R-T curves and in terms of their metabolic rates within the range of temperatures encountered in the course of their activities. The differences described here are suggestive of selection acting as fine tuning mechanism, adjusting the metabolic rate-temperature relations of the different populations to their specific environments.

SUMMARY

Samples of cricket frogs were collected in Texas and in South Dakota in July and acclimated for 5–7 days at 15 and 25° C. Routine metabolic rates were determined at 5, 10, 15, 20, 25, 30, and 35° C for samples from both localities acclimated at both temperatures. Sets of data from samples determined at each of the seven determination temperatures were subjected to a 2×2 analysis of covariance.

For both localities, warm acclimated (25° C) frogs had higher metabolic rates than cool acclimated (15° C) frogs at determination temperatures below 20° C (Texas) or below 25° C (South Daokta). At determination temperatures from 25 to 35° C (South Dakota) and 20 to 30° C (Texas), acclimation effects were not significant. At 35° C, Texas frogs acclimated at 15° C had a higher metabolic rate than those acclimated at 25° C.

Frogs acclimated at 15° C showed no significant locality effects when determined at 5, 10, 15, 25, and 35° C. At 20° C, the Texas frogs acclimated at 15° C had a significantly higher rate than the corresponding South Dakota frogs, while at 30° C, the South Dakota frogs had the higher rate. When both were acclimated at 25° C, the South Dakota frogs had a significantly higher rate than those from Texas at determination temperatures of 10, 15, 30, and 35° C. At 5, 20, and 25° C, however, no significant locality effects were apparent.

On the acutely measured R-T curves of cricket frogs acclimated at 25° C, there is a region of pronounced metabolic insensitivity to temperature in which region the Q_{10} approximates 1.0. The region lies between determination temperatures of 15–25° C for the South Dakota frogs and between 20–30° C for the Texas animals. Frogs from both localities acclimated at 15° C have a low Q_{10} value between 10–15° C and the Texas frogs have another one between 20 and 30° C. The differences noted above between the warm acclimated R-T curves of the northern and southern populations, taken in conjunction with published data on body temperature-environmental temperature relationships in *Acris* and with published climatological data, are consistent with the hypothesis of the role of metabolic patterns in the maintenance of metabolic stability in a varying thermal environment.

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